FutureGas

WP1

June

2018

WORK IN WP1

Main activities in WP1

Work finalized

Report 1.0. Gases in the scope of the project FUTUREGAS (with WP2). Report delivered end of 2016. Updated early 2017.

The report defines the gases within the scope of FutureGas. For further info, please refer to the summary of WP2.

- ***1.1 Report on upgrading of biogas to biomethane with the addition of hydrogen from electrolysis***

This report described the biological and catalytical methanation of biogas. The technical parameters regarding methanation are further summarized. Gas from various sources, such as syngas from thermal gasification, carbon dioxide (CO_2) captured from industrial point sources and CO_2 from biogas plants, can be utilized for biomethanation. During biological methanation, both H_2 can be added directly inside the anaerobic digestion or biogas, and H_2 can be added into a separate bioreactor, where the CO_2 is coupled with H_2 to produce CH_4 by consortium of mixed microbial species. In this report, methane production with addition of H_2 gas in biogas plants is described. Furthermore, existing demonstration, pilot plant and commercial biogas plant based on hydrogen-mediated biomethane are thoroughly summarized.

- ***1.2 Report on biogas upgrading***

Recently, several biogas upgrading technologies have been developed and commercialized. In this report, attempts have been made to summarize various biogas upgrading technologies and related concerns, such as market trends and gas quality requirements, based on recent literature. Furthermore, technological and economical aspects of biological methanation and biogas upgrading were described considering capital expenditure (CAPEX) and operating expenditure (OPEX) parameters. The widely accepted biogas upgrading technologies have been with more significance on their operation, cost benefit, methane loss, advantages and disadvantages, and their future potential for further commercialization has also been discussed.

- ***1.3 Scientific review article on microbial biogas enrichment***

A review article on microbial biogas enrichment is submitted to the Bioresource Technology Journal. This review provides a summary of scientific publication and numerous studies concerning biological methanation, biogas upgradation based on H_2 addition. Technical characteristics of anaerobic digestion, gas-liquid mass transfer limitation, and reactor design concern will be summarized. Challenges and modification of microbial dynamics due to H_2 addition inside the biogas reactor will be further discussed. This report will be used further in the FutureGas project, primarily to design the experiment based on present state-of-the-art on biological methanation.

- ***Biogas introduction in the grid***

A scientific paper has been finalized entitled Biogas introduction into the Danish gas grid system - A case study from demand perspective based on real flow data provided by Energinet. Furthermore, possibilities and limitations in relation to injecting biogas into the transmission grid are described.

Ongoing work

- ***Grid operation***

Different options for distributing biogas in the existing natural gas network are being examined. The analysis is based on real consumption data from an MR-station and biogas from a plant supplying gas to the same grid as the MR-station. The results are put into perspective in relation to production rate from biogas plants and consumption from other grids.
Furthermore, possibilities and limitations in relation to injecting cleaned (but not upgraded) biogas into the transmission grid are analyzed. The analysis is based on real flow data provided by Energinet.

➲ ***Syngas Production via biomass based fluidized bed gasifier reactor***

The stream at the exit of a gasifier reactor mainly contains CH_4, CO, CO_2 and H_2 called syngas. In the ongoing experiment, syngas is being produced from wood pellets, which will be coupled with methanogen, containing anaerobic digester, and then methane enrichment and gas purification will be done using microbes as catalyst.

Planned experimental work

➲ ***Biological methanation from syngas via biomass based fluidized bed gasifier reactor***

In the proposed experiment, the possibility of obtaining high methane yields from biomass through a two-stage process will be tested. Briefly, the gasifier to produce the syngas will be coupled with methanogens containing anaerobic digester, and then methane enrichment and gas purification will be done using microbes as catalyst. The experiment will be done at the laboratory of Danish Gas Technology Centre (DGC), effectively from June 2018.

➲ ***Change of biological methanation from syngas via biomass based fluidized bed gasifier reactor***

Microbes have a significant role in the anaerobic digestion process, which leads by a combination of pathways assigned by bacteria-archaea interactions. Briefly, bacteria hydrolyze polymers into monomers and then produce lactate, volatile fatty acids (VFA) and alcohols. Syntrophic bacteria further ferment to acetate, formate, H_2, and CO_2 that are utilized by methanogens as substrate in their metabolic process and produce methane. Thus, syntrophic interaction has a significant role to maintain the reaction spontaneously. Hence, understanding of microbial dynamics inside the anaerobic digestion is critical for process optimization. A parallel experiment will be designed to understand the dynamics of microbes during the biological methanation from syngas. Microbial samples will be sequenced to understand the performance and population dominance during the methanation process. The experiment will be done at the laboratory of Danish Gas Technology Centre (DGC) in collaboration with Arhus University, effectively from June 2018.

➲ ***Conversion of carbon dioxide into methane in bioelectrochemical systems (BES)***

The conversion of CO_2 into CH_4 by electromethanogenesis microbes is a promising emerging technologies for methanation. In bioelectrochemical systems (BES), microbes called electromethanogenesis utilize the electric current as a source of energy and carbon dioxide as a source of carbon to produce CH_4. This application has become an attractive alternative for biological methanation. However, there are still some limitations, such as reactor design, electron transfer mechanism from electrode to microbes and scaling up, that need to be solved to move further towards commercialization. Experiments on CH_4 production in bioelectrochemical systems (BES) will be performed at the end of 2018 at Arhus University. A published manuscript entitled “An overview of cathode materials for microbial electrosynthesis of chemicals from carbon dioxide" is a part of the experimental design to evaluate the technical aspects of the process.

Presentation and scientific publication

➲ **Presentation**

Invited presentations

- on biogas upgrading and gas utilization at Aalborg University, Copenhagen on 30th May 2018.
- on biogas upgrading technology at DTU Department of Chemical Engineering on 12th April 2018
- on Power-to-Gas at Arhus University on 20th November 2017.

Poster presentations

- Biological methanation. Presented on 8-9 May 2018 at Gastekniske Dage, Denmark
- Biogas introduction in gas grid. Presented on 8-9 May 2018 at Gastekniske Dage, Denmark

➲ **Published manuscript**

1. A review manuscript has been published in the Green Chemistry Journal entitled “An overview of cathode materials for microbial electrosynthesis of chemicals from carbon dioxide” (Aryal N. *et al.,* Green Chem., 2017,19, 5748-5760). In this review, further utilization and conversion of CO_2 to liquid chemicals (mainly acetate) via the microbial electrosynthesis route in bioelectrochemical systems has been discussed. This is followed by a discussion on carbon chain elongation from CO_2 to methane, acetate, ethanol, butyrate, butanol, isopropanol and propionate due to interactions between bacteria and electrode material. This report will be beneficial in the FutureGas project for experiment design on bioelectrochemical conversion of CO_2 to methane, which will be performed at Arhus University at the end of 2018. **(IF 9.1)**

➲ **Submitted manuscript**

1. A research article entitled “Biogas introduction into the Danish gas grid system - A case study from a demand perspective” has been submitted for publication in Frontier in Bioenergy and Biofuels Journal. (IF:- Open access journal)
2. A review article entitle “Microbial biogas enrichment: Emerging technologies for biogas upgrading” has been submitted to Bioresource Technology Journal. Importantly, the first major revision comments have been received. (IF 5.6)

INFORMATION

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